EXHIBIT I:

Mars UHF Proximity Antenna (MUPA)

Functional, Development, and Testing Requirements Document

June 18, 2004

Mars UHF Proximity Antenna (MUPA)

Functional, Development, and Testing Requirements Document

JPL D-28693 Version A

18 June 2004

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Jet Propulsion Laboratory
California Institute of Technology

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Functional, Development, Testing, and Documentation Requirements Document

D-28693 Version A

APPROVAL/CONCURRENCE SHEET

APPROVAL		CONCURRENCE	
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REVISION SHEET

VERSION	*DATE*	*AFFECTED PAGES*	*NOTES*
A	May 11, 2004	ALL	Initial Release

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TBD/TBR LISTING

Section Number	TBD
2	**JPL D-21090**, Date TBD, Draft C; Electra Payload Functional Requirements Document
Section Number	TBR
	Exterior Paint Finish for Thermal Conductivity

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Summary of Interface and Functional Requirements

Item No.	Paragraph	Parameter/Requirement Description	Point design (15 dB Gain)	Parametric study (15-20 dB gain range)
1.	3.1.1	Mass	**5 Kg (Goal: 3 Kg)**	**Outcome of study**
2.	3.1.2	Volume: stowed	**1400x1400x500 mm**	**Outcome of study**
3.	3.1.2	Volume: deployed	**1500x1500x2000 mm**	**Outcome of study**
4.	3.2.1	Frequency of Operation	**390-450 MHz**	**390-450 MHz**
5.	3.2.2.1	Antenna Connector	**SMA (Female)**	**SMA (Female)**
6.	3.2.2.2	Power Handling Capability	**15 Watts**	**15 Watts**
7. 8.	3.2.3 3.2.4	Impedance Return Loss	**50 Ohms** **-14 dB (VSWR: 1.5)**	**50 Ohms** **-14 dB (VSWR: 1.5)**
9. 9. 10 11. 12.	4.1 4.1.1 4.2.1 4.2.2 5.1	Polarization Axial Ratio (within HPBW) Peak Gain Sidelobes Vacuum Multipaction Breakdown	**RCP** **< 4 dB (<2 at Peak)** **15 dBic** **< 10 dB** **> 2x voltage**	**RCP, RCP/LCP Switchable** **< 4 dB (<2 at Peak)** **15-20 dBic** **< 10 dB** **> 2x voltage**

Table of Contents

1. SCOPE

This document defines the functional, interface, design, development, and testing requirements for the Mars UHF Proximity Antenna (MUPA), the primary element in the MTO UHF Antenna Assembly. Figure 1.1 shows the communication link scenarios for the MTO, and Figure 1.2 provides a spacecraft configuration.

Figure 1.1 MTO Communication Links

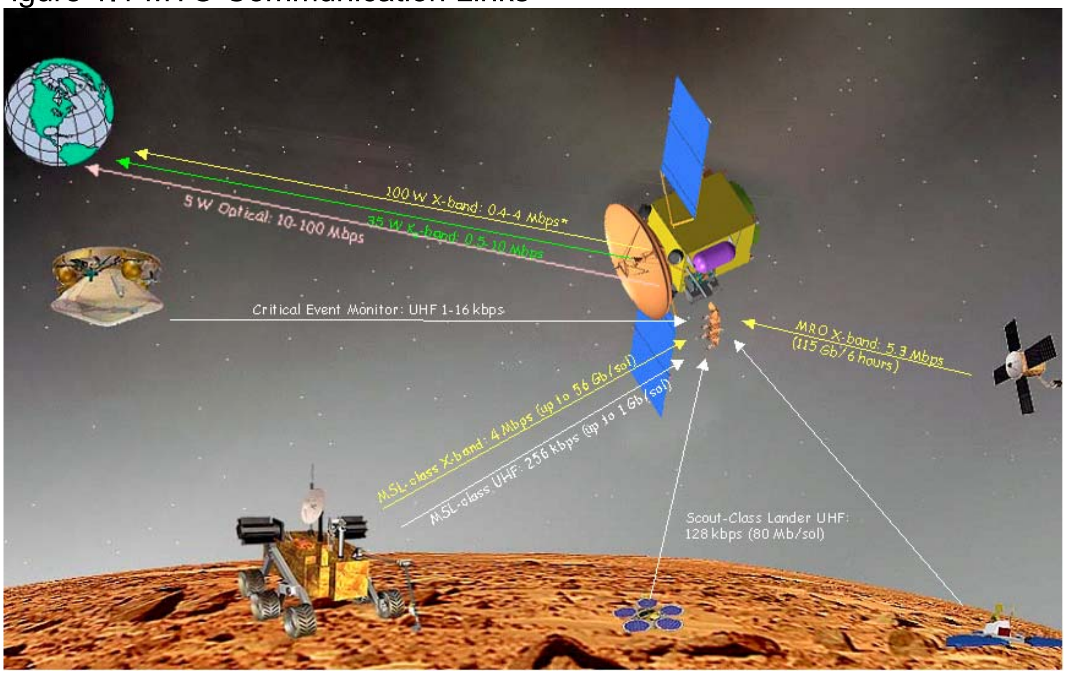
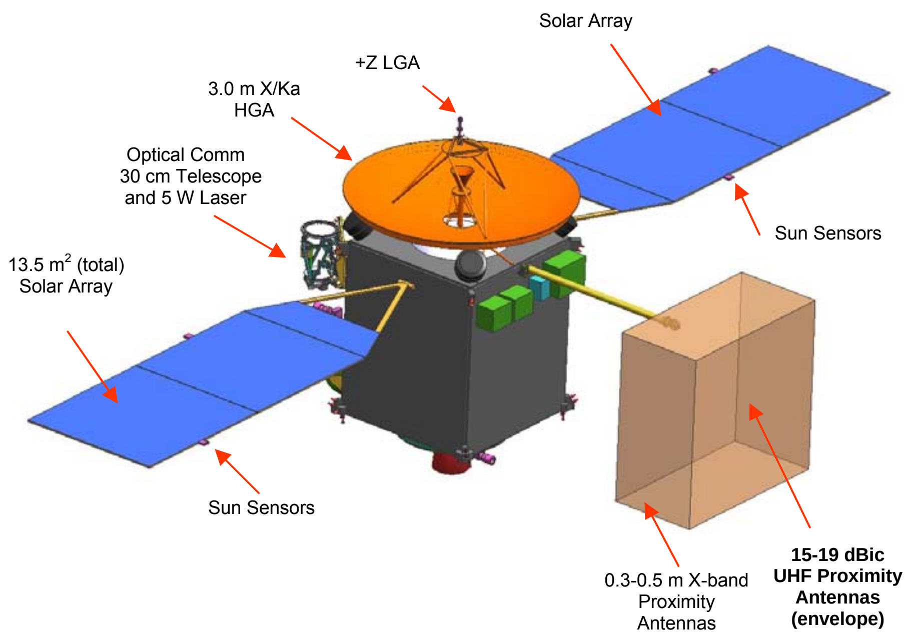


Figure 1.2 MTO Spacecraft Configuration



2. APPLICABLE DOCUMENTS

[1] **JPL D-26405**, JPL Oct. 8, 2003, MTO Environmental Requirements Document (Preliminary)

[2] **JPL D-29204**, DRAFT, June 22, 2004, Mars UHF Proximity Antenna Product Assurance Requirements Document

[3] ISO14644-1, Cleanrooms and associated controlled environments - Part 1: Classification of air cleanliness

[4] ISO14644-2, Cleanrooms and associated controlled environments - Part 2: Specifications for testing and monitoring to prove continued compliance with ISO 14644-1

3. External Interface Requirements

All specifications herein shall apply over the full environmental conditions such as temperature, aging, and radiation that are presented in Section 5.

3.1 Mechanical Requirements

3.1.1 Mass (TBR)

The mass of the antenna shall not exceed 5 kg (goal: 3kg).

3.1.2 Volume

In the stowed configuration, the antenna, including any mounting flange or plate shall fit within the following volume: 1400x 1400x500 mm.
In the deployed configuration, the antenna, including any mounting flange or plate shall fit within the following volume: 1500x1500x2000 mm.
The UHF antenna will be in close proximity to or integrated with an X-band flat-plate or reflector antenna with a diameter of less than or equal to 0.5 meters.

3.2 Electrical Requirements

3.2.1 Frequency of Operation

The antenna shall transmit and receive RF signals over the 390-450 MHz band

3.2.2 RF Interface

3.2.2.1 Antenna Connector

The input terminal of the antenna shall be an SMA female connector that is attached to the bottom of the antenna base.

3.2.2.2 Power Handling Capability

The antenna shall be capable of handling a continuous transmit power of 15 W over the frequency band of operation as specified in 3.2.1 in a vacuum environment while continuing to meet all performance requirements.

3.2.3 Impedance

The antenna input impedance across the over the frequency bands of operation as specified in 3.2.1 shall be 50 Ohms.

3.2.4 Return Loss

The antenna return loss shall not exceed -14 dB (VSWR: 1.5) across the operation bands in 3.2.1, on a characteristic impedance of 50 Ohms.

3.3 Ground Plane

The antenna shall be capable of meeting all requirements in this document without an external (to the antenna enclosure) ground plane.

3.4 DC Grounding

In order to provide a DC bleeding path for electrostatic discharging the antenna, the DC resistance between the coaxial inner and outer conductors and between any of the antenna arms and ground, shall be less than 1 Mega-Ohm.

4. FUNCTIONAL REQUIREMENTS

All specifications herein shall apply over the full environmental conditions such as temperature, aging, and radiation that are presented in Section 5.

4.1 Polarization

The antenna shall be right circularly polarized (RCP), over the frequency bands of operation as specified in 3.2.1. In the 15-20 dB trade-off study phase, the possibility of a switchable RCP/LCP configuration should also be addressed. The polarization purity level is defined below.

4.1.1 Cross Polarization

The axial ratio shall not exceed 2 dB at the peak and 4 dB within the half-power beamwidth (HPBW) region of the main beam.

4.2 Gain Pattern

The antenna patterns for both the baseline design and the trade-off cases will comply with the following specifications.

4.2.1 Peak Gain

The peak gain of the baseline antenna over the 390-450 MHz frequency band of operation as specified in 3.2.1 shall be a minimum of 15 dBic across the 390-450 MHZ frequency band, including all the losses. The peak gains of the trade-off cases (15-20 dBic) will cover the same frequency range and will include all the losses.

4.2.2 Sidelobes

The free space elevation gain pattern for the 390-450 MHz frequency band of operation shall have no side lobes higher than 10 dB from peak.

4.2.3 Beam Peak Direction

The peak gain of the antenna beam pattern at 390 MHz frequency shall correspond to the mechanical boresight. The direction of the peak gain of the antenna beam pattern, over the frequency bands of operation as specified in 3.2.1, shall be within 5 degrees of antenna mechanical boresight.

5. ENVIRONMENTAL REQUIREMENTS

The antenna design shall meet all the requirements specified in the latest revision of [1] and [2]and shall be self-compatible. Additional environmental requirements that the antenna shall meet, that may or may not be covered by the latest versions of the above documents are contained in the subparagraphs below.

5.1 Corona and Multipaction

The antenna shall not create corona or multipaction breakdown or electrical discharge under any operating mode or cycling of operating modes for any of the environmental conditions specified herein and in [1]. *Note: any susceptible parts (e.g., hybrids) shall be tested to a minimum power level of 6 dB above the maximum RF output power capability of the antenna for any corona and multipaction breakdown susceptibility.*

5.2 Launch Pressure Decay

The antenna shall be designed for payload fairing venting as shown in Figure 5.1-1. Alternatively, the antenna shall be designed for payload fairing venting with the maximum depressurization rate not exceeding 5.0 kPa/sec (0.73 psi/sec or 38 Torr/sec).

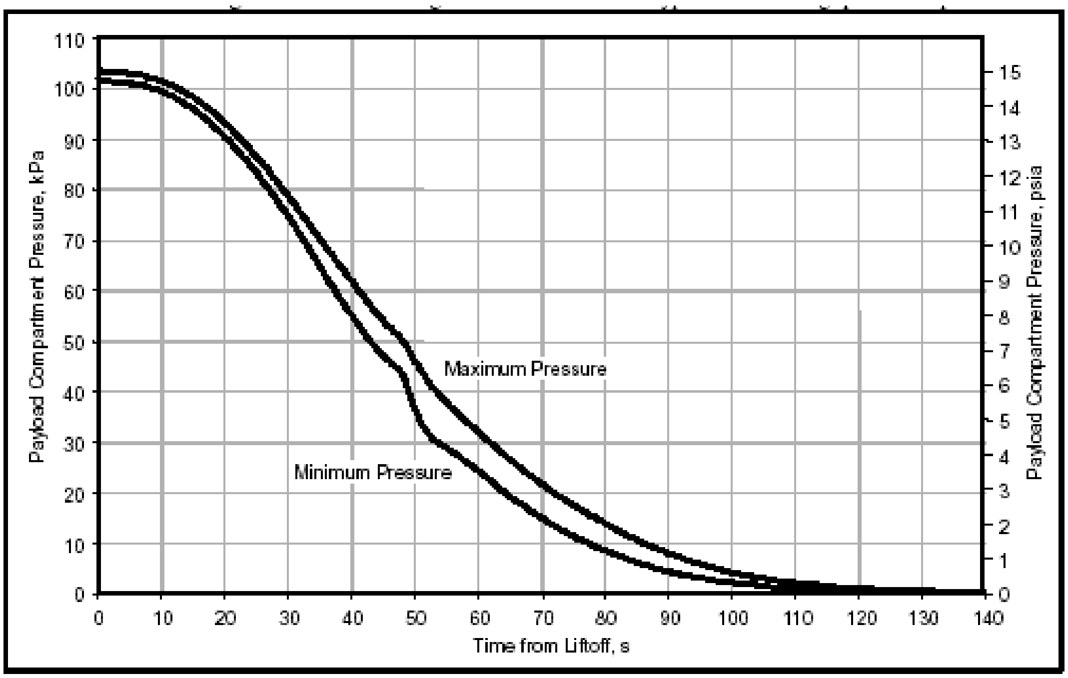


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Figure 5.1-1 Fairing Internal Pressure at Launch

6. DESIGN AND CONSTRUCTION REQUIREMENTS

The antenna shall meet all the requirements specified in the latest revision of[2]. Additional requirements that the antenna shall meet, that may or may not be covered by the latest version of the above document are contained in the subparagraphs below.

6.1 Unit Marking

Each unit shall be identified with the following information at a minimum:

(a) Contractor name
(b) Contractor cage code
(c) Model number
(d) Part number
(e) Contract number
(f) Serial number.

6.2 UHF Antenna Materials, Parts and Construction

6.2.1 Inspection

6.2.1.1 Test Flow Chart

A Test Flow Chart, that shows the fabrication and test flow of the Engineering Model (EM) antenna hardware shall be developed and approved by JPL.

6.2.1.2 Inspection Points

JPL Quality Assurance shall inspect the final EM antenna and any subassemblies or modules, including hybrids, not viewable at the final assembled level.

6.2.2 Approvals

JPL Quality Assurance shall approve all workmanship standards and critical process instructions.

6.2.3 UHF Antenna Engineering Models

EM antenna modules and assemblies shall utilize screened electronic parts in accordance with the requirements of the[2].

6.2.3.1 Fabrication

EM antenna modules and assemblies shall be in conformance with the JPL approved Contractors materials and process controls and workmanship standards.

6.2.3.2 Clean Room
All assembly and rework of the EM antenna modules and assemblies shall be in a controlled-access Class 100,000 clean room in accordance with [3].

6.3 Interchangeability and Replaceability
Each antenna shall be directly interchangeable in form, fit and function with other units of the same part number. The performance characteristics and dimensions of like items shall be sufficiently uniform to permit equipment interchange with a minimum of impact to link performance.

6.4 Materials Restriction
Cadmium, zinc and tin plating (unless tin is re-flowed) shall not be used in design and fabrication of the EM antennas.

6.5 External Finishes (External finishes will not be applied. This paragraph was intentionally left in to preserve original paragraph numbering designation)

6.6 Contamination Control
The antenna shall meet all of the requirements specified in the latest revision of the MRO Contamination Control Requirements contained in[2].

6.7 Planetary Protection
In anticipation of a subsequent flight unit, or the refurbishing of the EM for use as such, the design must be *compatible* with the Planetary Protection steps outlined below:

(a) During final antenna assembly all accessible component surfaces shall be thoroughly cleaned just prior to component installation.
(b) Antenna component surface cleaning shall be done using isopropyl or ethyl alcohol applied to clean, lint free wipes approved for class 100K clean room uses.
(c) After final antenna assembly and cleaning, the hardware shall be protected from recontamination
(d) The antenna shall be sealed in sterile bag(s) for shipment with connector savers installed
(e) Antenna dry heat microbial reduction of the final assembly will provide another option for reducing the bio-burden. This may be accomplished by subjecting the unit to 110 C for 50 hours up to 125 C for 5 hours a 1 torr (minimum exposure conditions).

6.8 Design Lifetime
In anticipation of a subsequent flight unit, or the refurbishing of the EM for use as such, the design must be *compatible* with the following operational requirements:

6.8.1 Mission Operational Lifetime

The antenna shall be designed for a minimum of eleven (11) years (1 year in cruise and 10 years in Mars orbit) continuous mission operation under worst case environmental condition as given in the latest revision of Reference [1] without any failure or performance degradation.

6.8.2 Ground Operational Lifetime

The antenna shall be designed to meet a minimum of two (2) years of ground testing without any failure or performance degradation.

6.8.3 Storage Lifetime

The antenna shall be designed for a minimum of two (2) years storage lifetime in the controlled environmental conditions as given in the latest revision of [1] without any damage or performance degradation.

6.9 Deployability and Stowability

Should the antenna require deployment, the EM model shall withstand repeatable deployment and stowing for test purposes.

6.10 Total Ionizing Dose (TID) Radiation

The antenna shall meet its functional and electrical performance requirements during and after exposure to the TID radiation level of 21 Krads (which includes a radiation design factor RDF=2) with equivalent Aluminum shielding thickness of 100 mils.

6.11 Venting

The antenna shall be constructed to provide a venting of all internal areas, exclusive of any components requiring hermetic sealing. The numerical ratio of volume, in cubic units, to vent area, in square units, shall be <2000.

6.12 Shipping and Storage Constraints

6.12.1 Storage and Shipping Containers

Appropriate handling fixtures or constraints shall be provided to protect the antenna during manufacture, testing, shipping, storage and installation. Storage and shipping containers shall provide a clean and dry environment for convenient hand carry aboard a commercial airliner.

6.12.2 Dust Caps

The coaxial interfaces on the deliverable antennas shall have dust caps installed for physical protection during shipping.

7. TEST REQUIREMENTS

The antenna test requirements are defined in this section. These test requirements are in addition to any test requirements required in any other portion of this document.

7.1 Test Procedure

A JPL approved Test Procedure shall be prepared that describes the details of the following tests:

(a) Functional and Performance Test Procedures
(b) Antenna Dynamic Test Procedures
(c) Antenna Thermal-Vacuum Test Procedures

7.2 Test Report

A JPL approved Test Report shall be prepared that will include the following for each test performed:

(a) Pretest Requirements
(b) Test Setup Description
(c) Test Method Description
(d) Test Method
(e) Data Requirements
(f) Failure Criteria
(g) Test Equipment List
(h) Data Sheets
(i) Safety Requirements.

7.3 Functional and Performance Tests

7.3.1 UHF Antenna Test Requirements

7.3.1.1 Tests

The antenna design shall be developed to allow the testing of all parameters defined in Table 7.3.1.1-1. Functional and performance tests shall include, but not be limited to, all parameters delineated in Table 7.3.1.1-1.

Table 7.3.1.1-1 Antenna Test Parameters

Antenna Parameter	Notes
Directivity	Frequency and direction
Gain	Frequency and direction
Polarization	Frequency and direction
VSWR	Versus temperature and frequency
Maximum Input Power	Power Handling Test in Vacuum

Environmental tests shall be conducted in accordance with latest version of [1] and [2], Section 2.2, Environmental Assurance. Additional requirements, that may or not be contained in [1] and [2]for Thermal Vacuum, Random Vibration, Pyroshock, and Electromagnetic Compatibility environmental testing shall be conducted on the EM antenna as described below.

7.4 Environmental Tests

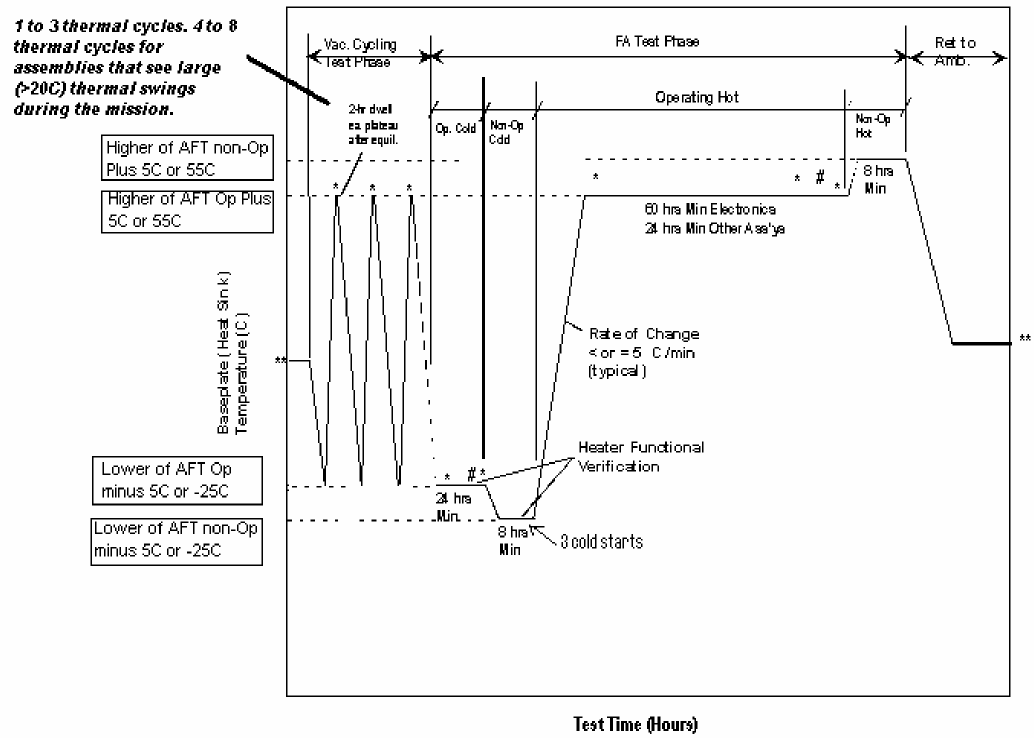
7.4.1 Thermal Vacuum Tests

Thermal vacuum tests shall be conducted in accordance with the following guidelines and tolerances:

(a) Time: ±15 Minutes
(b) Temperature: ±3 degree C
(c) Pressure: +2 to –5% from atmospheric to 10% of atmospheric, at vacuum conditions tolerances shall be such that a pressure of $1.33X10^{-6}$ kPa ($1x10^{-5}$ Torr) or less is assured, time rate of change: <30 degree C/Hour.

7.4.1.1 Protoflight Test (Required)

(a) The high and low temperatures shall be -125 to +135 C°.
(b) A total of eight (8) thermal-vacuum cycles shall be performed for all units. The temperature profile as given in Figure 7.4.1.1-1 shall be utilized.
(c) A one-hundred-forty-four (144) hour dwell is required at the hot temperature extreme and a twenty-four (24) hour dwell is required at the cold temperature extreme. Dwell times specified are for operational time; non-operational soaks do not count toward this time.
(d) At least 3 cold turn on /off and 3 hot turn on/off cycles shall be performed.
(e) Return loss shall be monitored during thermal vacuum/ temperature testing.



Notes
(1) Level shown is for electronics and mechanisms. Levels for other assemblies are AFT plus 5 C.
(2) Level shown is for electronics and mechanisms. Levels for other assemblies are AFT minus 5 C.
(3) Test environment is vacuum (i.e., pressure < 1.0E-5 torr).
(4) # indicates hot or cold starts - 3 times minimum, cold and hot.
(5) ** indicates pre- or post- test functional tests.
(6) * indicates required performance/functional tests after thermal equilibrium is established.
(7) Thermal equilibrium is defined as |dT/dt| <1 C/hour.
(8) Power on/off cycle test is not described in this profile.

Figure 7.4.1.1-1 MUPA Protoflight Testing Temperature Profile

7.4.1.2 Flight Acceptance Test (If required for retest)

Flight acceptance level retesting is allowed provided the MUPA Assembly has already successfully passed protoflight testing. Such retesting will be performed under the following conditions, or as approved by JPL:

(a) The high and low temperatures shall be -110 to +115 C°

(b) Six (6) thermal-vacuum cycles shall be performed, or as approved by JPL. The temperature profile as given in Figure 7.4.1.2-1, or as approved by JPL shall be utilized.
(c) A sixty (60) hour dwell is required at the hot temperature extreme and an eight (8) hour dwell is required at the cold temperature extreme. Dwell times specified are for operational time; non-operational soaks do not count toward this time.
(d) At least 3 cold turn on /off and 3 hot turn on/off cycles shall be performed.
(e) VSWR shall be monitored during thermal vacuum/ temperature testing.

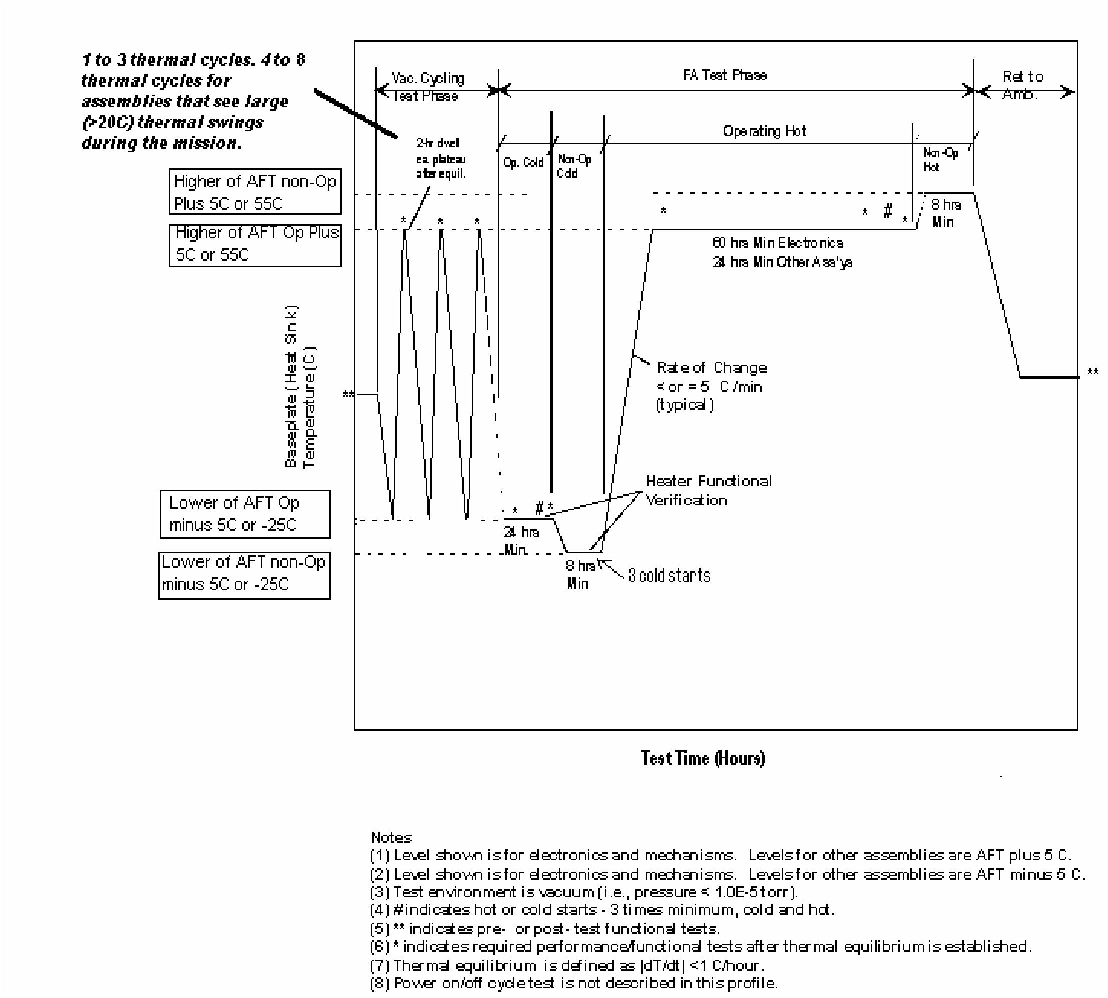


Figure 7.4.1.2-1 MUPA Flight Acceptance Testing Temperature Profile

7.4.2 Random Vibration Testing

Protoflight and Flight Acceptance random vibration tests shall be conducted in each of three orthogonal axes with the vibration spectrum as specified in Table 7.4.21. The random vibration levels shall have a Gaussian distribution. Test tolerances shall be:

a) Duration time: +/- 5%
b) Vibration frequency: +/- 5% or 1 Hz whichever is greater
c) Vibration levels/Grms: +/- 1dB
d) PSD: +/- 3 dB max frequency band=25Hz.

Automatic, closed-loop equalization shall be used for control. The antenna shall be mounted to a fixture through the normal mounting points of the unit.

Control accelerometers shall be mounted on the fixture near the antenna attachment points. The vibration fixture shall be verified by test to uniformly impart motion to the antenna (within ±3 dB) in the direction of shake. Cross axis inputs shall be lower than the shake axis inputs.

Table 7.4.2-1 MTO Random Vibration Requirements

Assembly/ Assembly	Frequency, Hz	FA Level	Qual, PF Level
Electra	20 20-55 55 - 300 300-2000 2000 OA	0.055 g^2/Hz 3 dB/octave 0.15 g^2/Hz -5 dB/octave 0.02 g^2/Hz 10.7 grms	0.11 g^2/Hz 3 dB/octave 0.3 g^2/Hz -5 dB/octave 0.04 g^2/Hz 15.1 grms

Qualification exposure time, 2 minutes in each of 3 axes
Protoflight and Flight Acceptance exposure time, 1 minute in each of 3 axes

Table 7.4.2-2 Assembly Random Vibration Force Limit Specifications

Frequency, Hz	Force Spectral Density Level
$f < f_o$ $f \geq f_o$	$S_{FF} = C^2 M_o^2 S_{AA}$ $S_{FF} = C^2 M_o^2 S_{AA} (f_o/f)^2$

Where:
f = frequency, Hz
f_0 = frequency of the primary mode, i.e. the mode with the greatest effective mass, Hz
S_{FF} = the Force Spectral Density
C = a dimensionless constant which depends on the configuration
M_0 = total mass of the test item, kg
S_{AA} = Acceleration Spectral Density

Before and after the test in each axis a low-level sine survey should be conducted to verify that no significant frequency shifts have occurred. During the test, the antenna shall be electrically energized and functionally sequenced through various operational modes to the maximum extent practical. The insertion loss shall be continuously monitored for failures or intermittent behavior during the test.

The random vibration tests shall be conducted in each of three orthogonal axes in accordance with the following subsections.

7.4.2.1 Protoflight Acceptance Test (required)

Protoflight acceptance level testing is allowed provided the Antenna Assembly has already successfully passed protoflight tests. Such retesting will be performed under the following conditions, or as approved by JPL:

(a) The test duration shall be one minute per axis.

(b) The vibration spectrum shall be as specified in Table 7.4.2-1 and Table 7.4.2-2.

7.4.2.2 Flight Acceptance Test (required)

Flight acceptance level testing is allowed provided the antenna has already successfully passed protoflight testing. Such retesting will be performed under the following conditions, or as approved by JPL:

(a) The test duration shall be one minute per axis.

(b) The vibration spectrum shall be as specified in Table 7.4.2-1 and Table 7.4.2-2.

7.4.3 Pyrotechnic Shock Design Requirements

The antenna shall be designed to survive the maximum of the Shock Response Spectrum (SRS) levels specified in table 7.4.3.1.

Table 7.4.3.1 UHF Antenna SRS (Q=10) Design Levels

Frequency, Hz	FA SRS Level	Qual, PF SRS Level
100	20 g	40.0 g
100 - 1000	+10.5 dB/octave	+10.5 dB/octave
1000 - 10,000	1420 g	2000 g

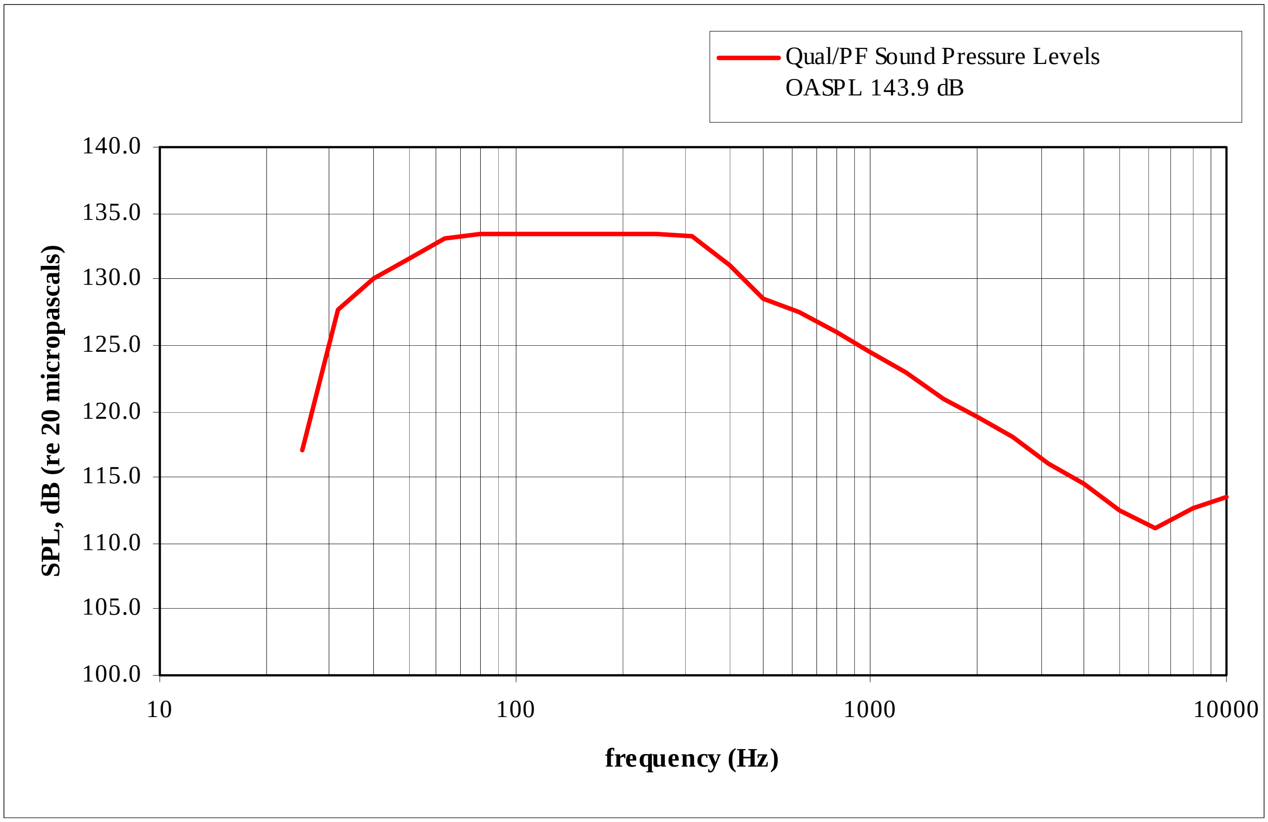
7.4.4 Acoustic Noise

The acoustic noise requirement for both the system and assemblies is a reverberant random-incidence acoustic field specified in 1/3 octave bands. The acoustic noise spectra for the candidate launch vehicles are specified in Table 4.4.7-1 and Figure 4.4.7-1. The exposure duration is two minutes for Qualification test and one minute for

Protoflight test. The test article shall be in its launch mechanical and electrical configuration. The flight spacecraft shall be installed on the test Payload Adapter Fitting. Assemblies shall be hung by bungee cords or otherwise vibration isolated from acoustic chamber surfaces.

The overall acoustic sound pressure level (OASPL) shall be controlled to within ±1dB (true RMS) of the specification values. The test should be controlled so that the square root of the average mean-square sound pressure at several locations surrounding the test article meets the test levels specified in the table, in 1/3 octave bands centered on the specified frequency. The control microphone locations should be 30.5 to 45.7 cm (12 to 18 inches) from major exterior surfaces of the assembly or subsystem. The control microphones and their data acquisition systems shall have flat frequency response characteristics within ±1 dB from 30 Hz to 10 kHz. A minimum of four microphones shall be used to control the test.

Figure 7.4.4-1 Qual/PF Sound Pressure Test Levels for Candidate Launch Vehicles*



* Candidate launch vehicles enveloped are: Delta IV 4450-14; Atlas V 401, 511, 531, 541, 551

Table Figure 7.4.4.-2 Qual/PF Sound Pressure Test Levels for Candidate Launch Vehicles

1/3 Octave Band Center Frequency (Hz)	Qual/PF Sound Pressure Levels (dB re 20 μPa)	Test Tolerances (dB)
25	117.0	+5, -3
31.5	127.6	+5, -3
40	130.0	+5, -3
50	131.5	+5, -3
63	133.0	+3, -3
80	133.5	+3, -3
100	133.5	+3, -3
125	133.5	+3, -3
160	133.5	+3, -3
200	133.5	+3, -3
250	133.5	+3, -3
315	133.2	+3, -3
400	131.0	+3, -3
500	128.5	+3, -3
630	127.5	+3, -3
800	126.0	+3, -3
1000	124.5	+3, -3
1250	123.0	+3, -3
1600	121.0	+3, -3
2000	119.5	+3, -3
2500	118.0	+3, -3
3150	116.0	+3, -3
4000	114.5	+3, -3
5000	112.5	+3, -3
6300	111.1	+3, -3
8000	112.7	+3, -3
10000	113.5	+3, -3
OASPL (dB)	**143.9**	**+1, -1**